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A Reconfigurable Microstrip Antenna Array Using SPST Switches at UMTS Band

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ABSTRACT

The work undertaken is the proposal and simulation of a reconfigurable microstrip antenna array for adaptive base station operating in the UMTS frequency band. Our array antenna is performed with Fr4 (Er = 4.5 tgδ = 0.02 h = 1.6mm). The basic antenna array is constituted of circular patches adapted with coplanar notches and circular patches parasite fed by electromagnetic coupling. The system also integrates a SPST switches.
The simulations are performed with the ADS software.

Key words : Microstrip antenna array, parasitic patches, SPST switches, reconfigurable antennas.

1. INTRODUCTION

Antennas have experienced a very great development in recent times and that in the order to follow the great growth experienced by the field of telecommunications. This development brings up news concepts of smart antennas [1]. We can cite as an example; the broadband antennas with variable frequency [2], the reconfigurable antennas and the adaptive antennas.

Adaptive antennas system can determine the location of the user and try to focus and receive energy only in desirable directions. This concept is made even better we combinate a smart antenna systems with planar design technology witch allows easier integrability of active microelectronic components in the antenna. The design of adaptive antennas is an important challenge which includes the development of switches, efficient and compatible with standard manufacturing methods in microelectronics.

The integration of switches in the same process that antenna allows the minimization of costs of production. In this perspective we undertook this work that propose and simulate adaptive microstrip antenna array architecture for UMTS application [3].

Our array antenna consists of two separate subnets; the first subnet is called scan subnet. Its role will be to detect users and memorizing their locations.

The second subnet is the distribution network, it responsible to generate the radiation pattern that the structure is calculated by the first subnet [4]. This antenna will be realized with microstrip technology, and will consist of a tree structure network that composed of elementary circular patches produced with the Fr4 (Er = 4.5 tgδ = 0.02 h = 1.6mm). The system also incorporates a SPST and SP4T switches.

2. CONCEPTION OF A RECONFIGURABLE MICROSTRIP ANTENNA FOR UMTS USE

This network consists of: Eight circular patches adapted with coplanar notches and fed by microstrip lines preceded by couplers. Parasitic patches distributed under tree architecture and fed by electromagnetic coupling. This network allows four beams with different distribution angle by to activate or deactivate network branch. For this, we used SPST (single pole single throw) switches based on PIN.

2.1 SPST switcher conception and simulation

Based on studies performed to realize a SPST switch based on PIN diode [5], the operating principle of this device is: when the voltage is positive the diode is conducting and the load resistor in the output circuit is short circuited and thus the input signal is blocked. When the bias voltage is negative, the diode is blocked and the input signal is routed to the output [6].

The function of the bias supply lines is to inject bias current. Thesehighimpedance lines (147 Ohm to 100micro ns) must present a impedance transmission line close to that a open circuits in order to not disrupt the RF energy transmission [7]. Thus, the capacity of high value 100 pF is added in parallel to λ /4 RF lines. The diode chosen for this application is HPND PIN 4028 (sold at 23 € per unit) [8].

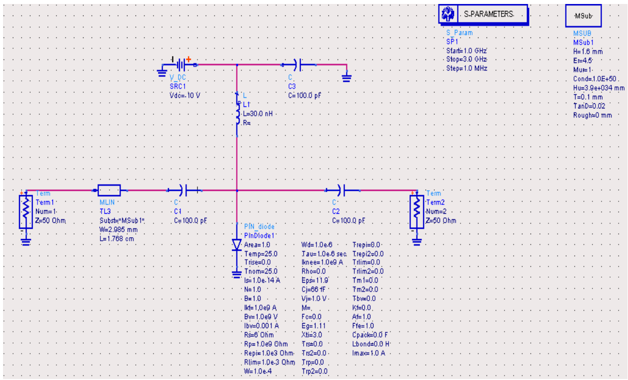

Figure 1: A SPST based diode PIN electrical schema

The ADS tool allows the direct generation of Layout to move to the design of the switch.

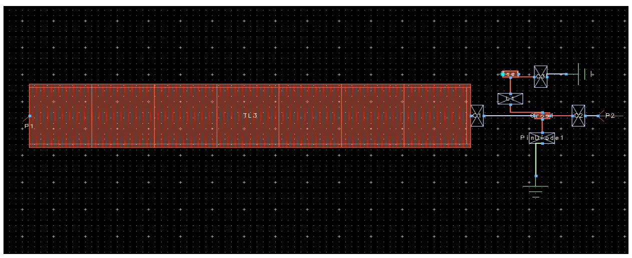

Figure 2: Layout of SPST switch

When the SPST is in reverse bias, as is clearly shown in the figure below, we will notice that the signal is routed to the output. The reflection coefficient is set to-33.7dB.

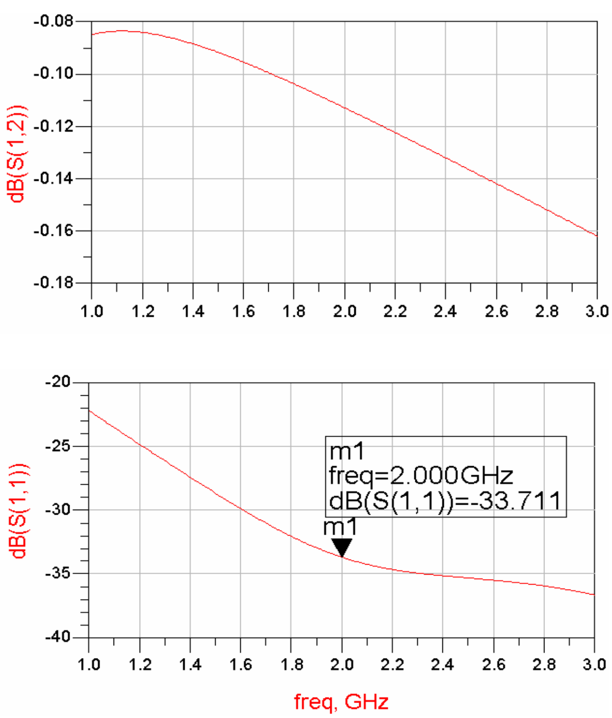

Figure 3: The SPST Simulation Results in reverse bias

In case where the circuit is biased directly, the following figure illustrates that the input signal is blocked and the I

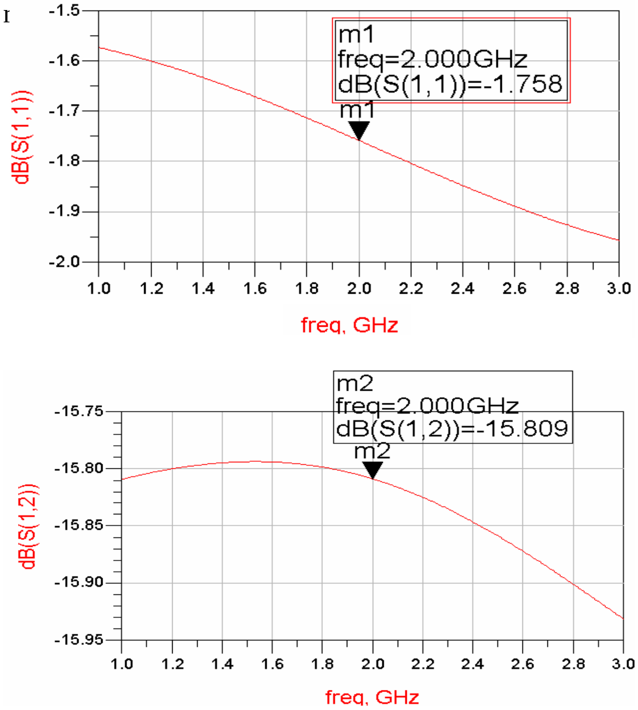

Figure 4: The SPST simulation results in direct bias

2.2 The array simulation

The SPST switch simulated in the previous section is integrated into the distribution subnet in order to activate or deactivate network branch. This transaction will allow us four different radiation pattern openings. The switch replaces the line λg /2 in each branch of the network as illustrated by the following figure. Its location is chosen so as not to disturbt the antenna characteristics.

The total scheme of distribution subnet under comprises six switches SPST connected to each line to permit blocking the signal in the desired branch and therefore the reconfiguration of the radiation pattern of the antenna.

The antenna consists of a network of circular patches fed by microstrip line and distributed in a tree structure that allowed a good performance [9]. The patches distribution structure has been inspired by the YAGUI-UDA antenna. The eight patches supplied by microstrip lines represent the radiator element, and the patches supplied by electromagnetic coupling represent the director element of the antenna.

The distribution of parasitic patches will be made in order to take into account the future functionality of sub-networks, where the difference between the two structures used: For scanning network, the tree structure is a single branch [9]. However, for the distribution network, the structure is in four branches.

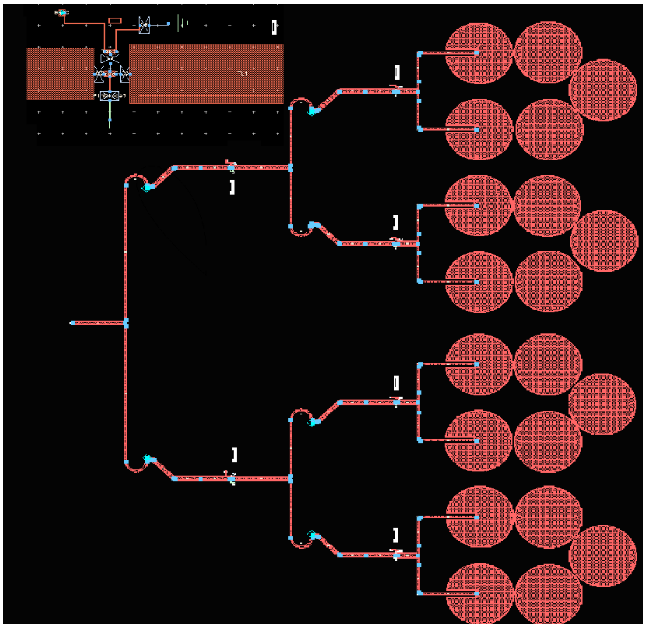

Figure 5: Layout of distribution subnet

The parasites patches present an electromagnetic coupling in the E and H planes. The connecting lines should be sized to be adapted to 50 Ohms at the input of the array.

Wilkinson dividers "which divides the power keeping the same input impedance to the output [10]" were integrated in order to obtain an impedance of 100 Ohm at the entrance of the patches. The antenna circuit is well illustrated in the figure7.

Based on the simulation results this network allows a reflection coefficient about -27dB.

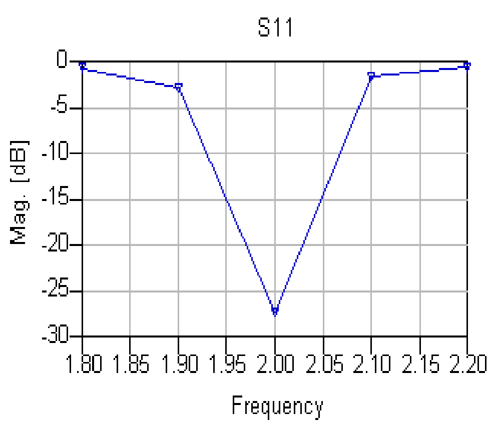

Figure 6: Simulation results of subnet distribution

To better visualize the performance of this network, we proceed to the simulation of the radiation pattern for the different states of the switches in the subnet.

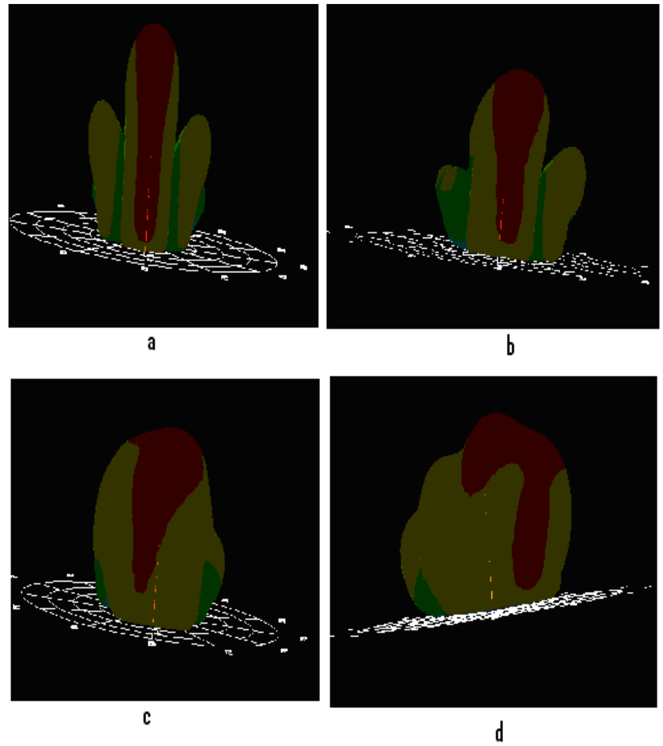

Figure 7: Radiation pattern the reconfigurable microstrip antenna

- Four active branches

In this case, the four subnet branches are fed; the switches are biased in reverse. The main lobe of the subnet is highly directional. Its effective angle is about 42 degrees. This subnet allows a directivity of 12 dB and a gain of 11.8dB.

- Three active branches

In this case, three subnet branches are fed. Three switches are in reverse bias and one switch in direct. The main lobe of the network is less directive than the first case. Its effective angle is 50 degrees. This network allows a directivity of11.5dB and a gain of 11dB.

- Two active branches

Now, two subnet branches are fed. Two switches are in reverse bias and two in direct. The main lobe of the subnet is less directive than the first and second cases. Its effective angle is about 71 degrees. This subnet allows a directivity of 10 dB and a gain of 9.5dB.

- One active branch

In this case, only one branch of the subnet is fed. One switch is in reverse bias and the others are biased directly. The main lobe of the subnet is less directive than the first and second cases. Its effective angle is 71 degrees. This subnet network allows a directivity of 10 dB and a gain of 9.5dB. Although the power is cut on the inactive branches, the influence by electromagnetic coupling remains active, which explains the high gain and directivity.

3. CONCLUSION

In this paper we proposed and simulated a reconfigurable microstrip antenna array for adaptive base station. This antenna allows the reconfigurability of the radiation pattern. The transmission and reflection coefficients simulations results of the distribution subnet, consisting of four distinct branches connected to SPST switches, are been very favorable. The radiation pattern showed the existence of four different opening for the fields according to the active branches.

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